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Wang et al.

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(45) **Date of Patent: *Dec. 11, 2012**

(54) **PIEZOELECTRIC AND SEMICONDUCTING COUPLED NANOGENERATORS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1763 days.

This patent is subject to a terminal disclaimer.

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
H01L 27/20 (2006.01)

(52) **U.S. Cl.** **257/41**; 257/43

(58) **Field of Classification Search** 257/41–43, 257/E27.006; 977/701, 720, 721, 722, 724, 977/725, 730, 832, 837, 932, 948
See application file for complete search history.

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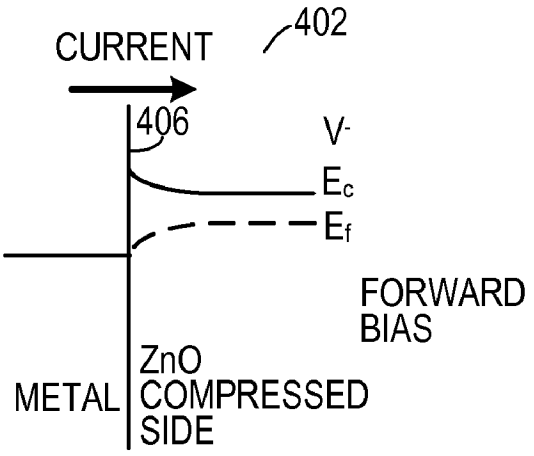
(57) **ABSTRACT**

An electrical generator includes a substrate, a semiconductor piezoelectric structure having a first end and an opposite second end disposed adjacent to the substrate, a first conductive contact and a second conductive contact. The structure bends when a force is applied adjacent to the first end, thereby causing an electrical potential difference to exist between a first side and a second side of the structure. The first conductive contact is in electrical communication with the first end and includes a material that creates a Schottky barrier between a portion of the first end of the structure and the first conductive contact. The first conductive contact is also disposed relative to the structure in a position so that the Schottky barrier is forward biased when the structure is deformed, thereby allowing current to flow from the first conductive contact into the first end.

25 Claims, 5 Drawing Sheets



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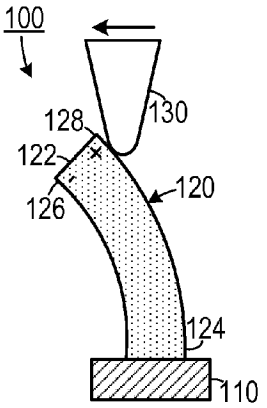

FIG. 1A

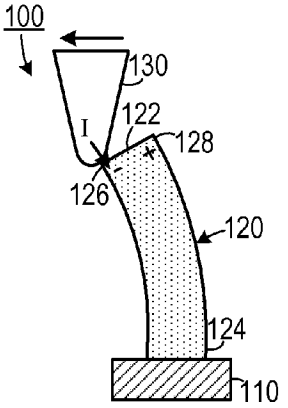

FIG. 1B

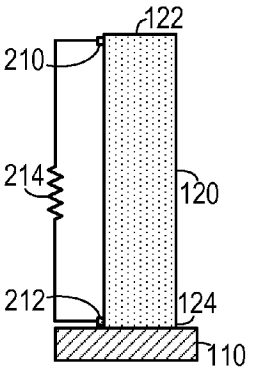

FIG. 2A

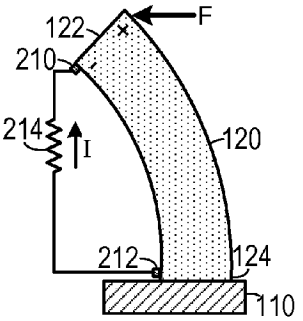

FIG. 2B

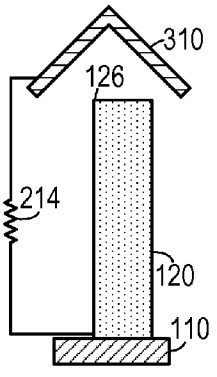

FIG. 3A

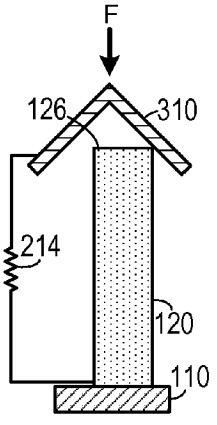

FIG. 3B

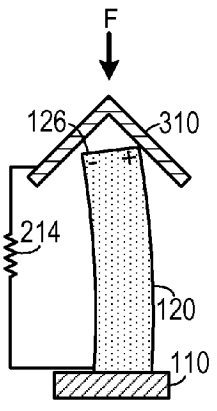

FIG. 3C

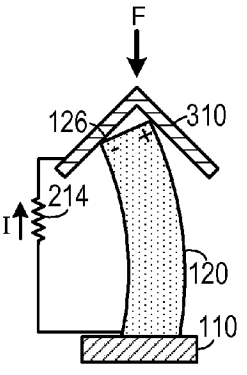

FIG. 3D

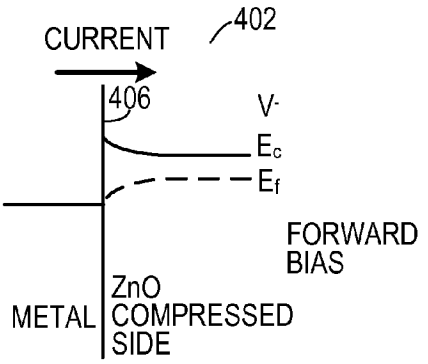

FIG. 4A

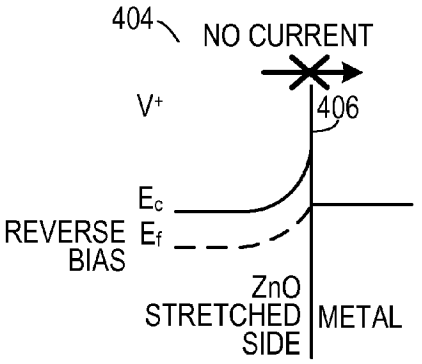

FIG. 4B

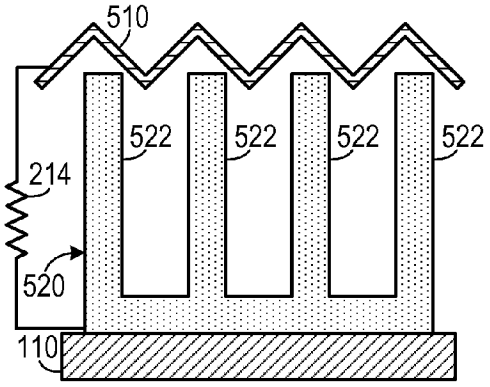

FIG. 5A

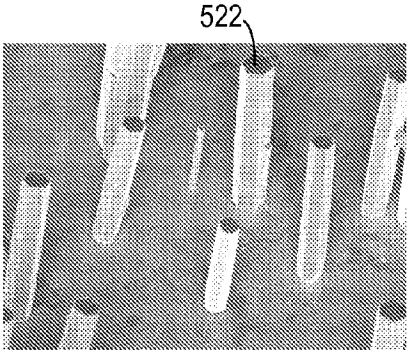

FIG. 5B

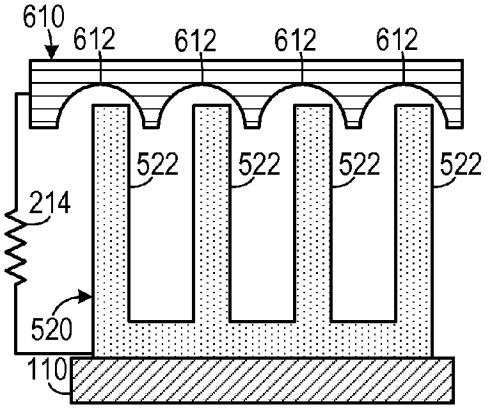

FIG. 6A

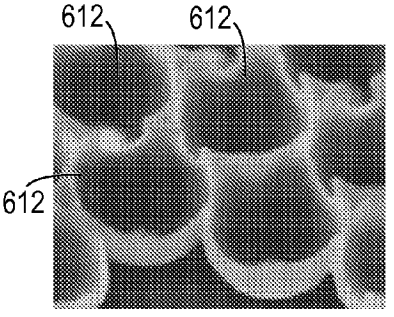

FIG. 6B

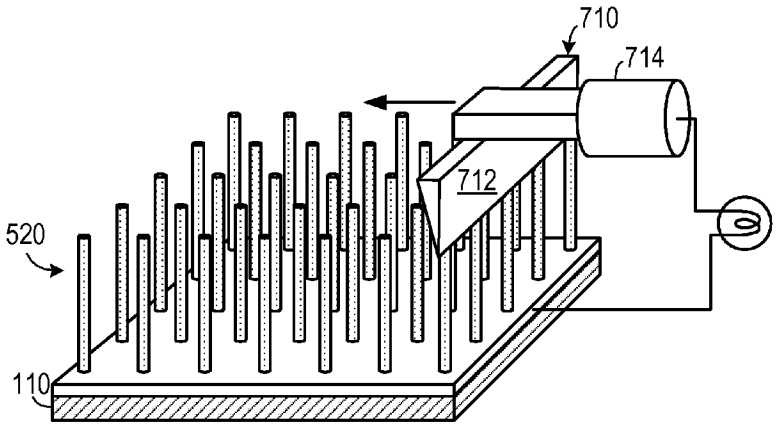

FIG. 7

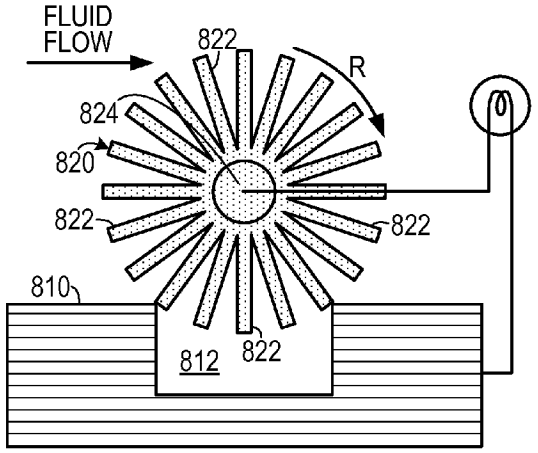

FIG. 8A

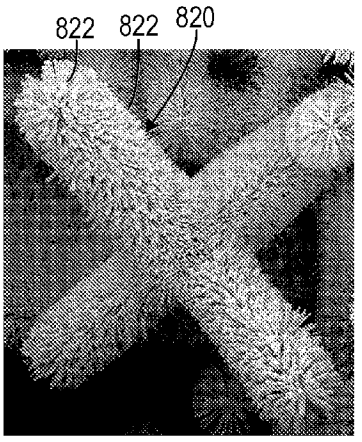

FIG. 8B

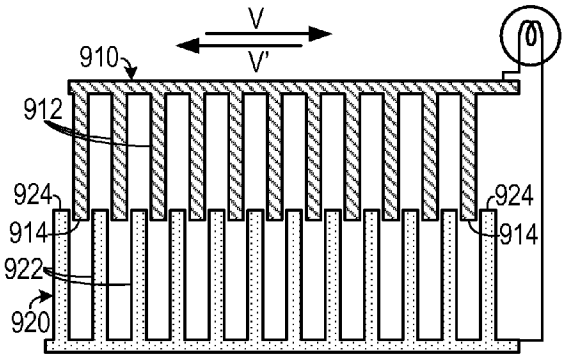

FIG. 9A

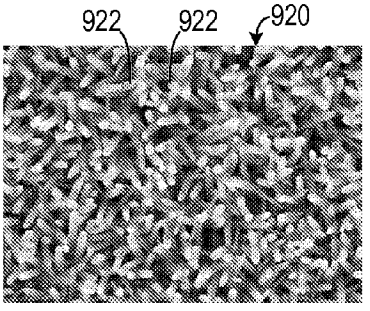

FIG. 9B